

U T A H G E O L O G I C A L S U R V E Y

SURVEY NOTES

Volume 32, Number 2

May 2000

Wasatch Front Landslides



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Design by Vicky Clarke

Cover: UGS geologist, Richard Giraud, investigates main scarp of the Capitol Boulevard-City Creek landslide in Salt Lake City. Photo by Francis Ashland.

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The Director's Perspective

by Kimm Harty

This issue of Survey Notes focuses on geologic hazards, with emphasis on landslides in Utah that occurred during the El Niño years of 1997-8. This past January, during the 2000 Utah legislative session, I showed members of the Natural Resources Appropriations Committee photographs of new landslide damage that had just occurred in some of their districts. Our committee members expressed extreme disappointment that residential subdivisions are still being constructed in Utah in areas prone to landslide hazards. We at the UGS are also disheartened to see this "trend" continuing. Historically, landslides have probably cost Utahns more than any other natural hazard except perhaps flooding.

Responsibility for land-use planning, zoning, and construction permitting lies with local governments (counties, cities). Although the state has no statutory authority to regulate subdivision development, the state tasks the UGS with providing assistance to local governments on geologic-hazards issues. At present, the UGS meets this charge in part by: (1) preparing geologic-hazards maps throughout the state for use in local government geologic-hazards ordinances; (2) reviewing consultants' geotechnical reports for geologic adequacy upon request of local governments; (3) performing geologic-hazards reviews and investigations for critical public facilities (schools, fire stations, etc.); and (4) providing advice to local government planners on geologic-hazards issues. Yet building in geologically unstable areas continues, especially as more suitable land along the

Wasatch Front disappears. Pressure to develop these "geologically challenged" lands increases as time passes and land in the most sought-after communities becomes scarce.

Can the UGS ensure safe development? Not entirely, but we realize that more needs to be done to increase the awareness of hazards, especially landslide hazards, among community leaders and citizens. In this coming year, the UGS Applied Geology Program is formalizing its internal landslide mitigation plan. We will formulate actions that the UGS hazards geologists will follow to reduce losses from future landsliding, including debris flows. This plan will set long-term goals as well as identify specific projects we will undertake to help us preserve lives, property, and economic resources.

Our plan will probably parallel many of the goals and actions included in the Federal Government's National Earthquake Hazard Reduction Program (NEHRP). We anticipate our own "Landslide Hazard Reduction Program" will become a cooperative effort with, and perhaps be partly supported in the future by, the U.S. Geological Survey, which is currently in discussion and planning stages to create the "National Initiative for Landslide Hazards Mitigation." Substantive landslide research and hazard-reduction planning in Utah is needed. The landslides of 1997-8 made that apparent, and we hope to capitalize on this increased awareness to improve land-use practices in Utah to reduce future landslide losses.

Survey Notes is published three times yearly by Utah Geological Survey, 1594 W. North Temple, Suite 3110, Salt Lake City, Utah 84116; (801) 537-3300. The UGS inventories the geologic resources of the state, identifies its geologic hazards, disseminates information concerning Utah's geology, and advises policymakers on geologic issues. The UGS is a division of the Department of Natural Resources. Single copies of Survey Notes are distributed free of charge to residents within the United States and Canada and reproduction is encouraged with recognition of source.

Lessons Learned from the 1998 Wasatch Front Landslides

by Francis X. Ashland

Introduction

In 1998, direct losses in Utah resulting from landslides were perhaps the highest since the years between 1983 and 1986, a period of above-normal precipitation during which significant landsliding occurred, particularly in 1983. As of March 1999, estimated landslide costs at Sunset Drive in Layton exceeded \$450,000 including the loss of two houses, one destroyed and demolished in 1998, another severely damaged and abandoned by early 1999. In the City of North Salt Lake, an imperceptibly slow-moving landslide caused such severe damage to one house that the city building inspector was forced to condemn it. Elsewhere, in Salt Lake City and Provo, other homeowners spent more

than the value of their equity attempting to prevent damage from landslide movement. Estimated landslide losses in 1998, mostly to residential properties, exceeded \$1 million. In most cases, damage caused by landsliding is not covered by typical homeowner's insurance. Thus, most of the losses in 1998 were incurred directly by the homeowners.

By early April 1998, the above-normal precipitation that had come in the winter, mostly as snow, had melted from the lower elevations along the Wasatch Front. However, above-normal precipitation continued as rain, while snow continued to accumulate at higher elevations in the Wasatch Range. The "excess" precipitation, the amount above normal for an aver-

age year, infiltrated the soil and caused ground-water levels to rise. On many moderate to steep slopes, particularly ones that had experienced landsliding in the past, the rising ground water reduced the ability of soils to resist the force of gravity. Eventually, stability thresholds were reached at these landslides and they began sliding. This happened earliest at recently active landslides such as the Shurtz Lake landslide in Spanish Fork Canyon, and then later at older, dormant landslides like those in Layton. By the end of the month, damaging landslide movement was occurring in South Weber, Ogden, and Ogden Valley. By May landsliding was occurring in the City of North Salt Lake, Salt Lake City, and Provo. Sometime in May the Thistle land-

Estimated direct losses as of March 1999, Sunset Drive landslide, Layton.

Description of Loss	Estimated Value (dollars)	Source of Loss Estimate
House at lot 105 (demolished)	\$200,000	Deseret News, April 21, 1998
House at lot 104 (abandoned)	\$200,000	Deseret News, April 21, 1998
Demolition of house at lot 105	\$ 10,000	Standard Examiner, October 20, 1998
Geotechnical slope-stability investigation	\$ 40,000	Deseret News, October 15, 1998
Relocation fees for family at lot 105	\$ 6,000	Standard Examiner, September 10, 1998
Subtotal Value of Direct Losses	\$456,000	

slide began moving again. This landslide had moved catastrophically in 1983, blocking the Spanish Fork River with debris and inundating the community of Thistle as a lake formed upstream of the blockage. The 1998 movement damaged a fence and threatened a new buried water line that crossed the toe of the 1983 landslide.

Given the significant losses from landsliding in 1998, it is important to consider what lessons can be learned from these events. If we can further the understanding of landslide hazards by geologists, engineers, and local officials and land-use planners, we can improve our ability to protect the public and their property from the hazard.

Lesson one: Above-normal precipitation causes landsliding

Utah was reminded in 1983, and again in 1998, that periods of above-normal precipitation can trigger landsliding. Both years were preceded by successive years with above-normal precipitation. In Salt Lake City, the seven years between 1980 and 1986 all had above-normal precipitation, and 1983 was the wettest year since 1875 when record keeping began. This was also the wettest year on record in Ogden and in Spanish Fork Canyon (Thistle). During the seven above-normal-precipitation years in the Salt Lake area, an average of 3.5 inches of excess (above-normal) precipitation fell each year. In comparison, between 1995 and 1998, a four-year period of above-normal precipitation, an average of 2.4 inches of excess precipitation fell each year. And in Salt Lake City, 1998 was the second wettest year on record. The "excess" precipitation during these periods caused ground-water levels in slopes to rise toward critical threshold levels at which landsliding triggered. It took about three years in the early 1980s for the cumulative effects of the excess precipitation to trigger landsliding, which increased in frequency by late 1982. Similarly, between two to four years passed in the late 1990s



Landslide damage at a lot on Capitol Boulevard, Salt Lake City, June 1998. Landslide movement formed a scarp and offset the backyard of the home by more than 5 feet. Fence in background and underground piping to sprinkler system were damaged by movement.



Severe damage to a house on the Sunset Drive landslide, Layton, April 1998. House was subsequently condemned by Layton City and demolished.

before a noticeable increase in the number of landslides occurred in early 1997.

Unfortunately, many scientists and engineers made one conclusion in the late 1980s that proved incorrect, namely that the above-normal precipitation that, in most areas, ended in 1986 was anomalous or extraordinary. This conclusion was likely reached because successive years with above-normal precipitation, like that which occurred between 1980 and 1986, had rarely occurred before. In Spanish Fork Canyon, no successive years with above-normal precipitation had occurred between 1928 and 1979. However, by the mid-1990s, another successive period of above-normal precipitation years had started. At six landslide areas, the four wettest years in the last 50 to 70 years have occurred since 1980. This skewness in the precipitation record indicated by

the wettest years having occurred mostly in the last 20 years indicates that the relatively short precipitation record does not adequately characterize Utah's short-term climatic fluctuations and suggests that the "wettest" year in any locality could be just a few years in the future.

Lesson two: Pre-existing landslides are more likely to move, but won't necessarily

The majority of landslides in 1998 were within pre-existing landslide areas. In only one case, the Springhill landslide in the City of North Salt Lake (see accompanying article), was a 1998 landslide apparently in an area without a known pre-existing landslide. Gravel extraction and subsequent re-grading may have obscured pre-existing landslide features in this area, however. Geologists inferred that many of the 1983 landslides were also in pre-existing landslide areas.

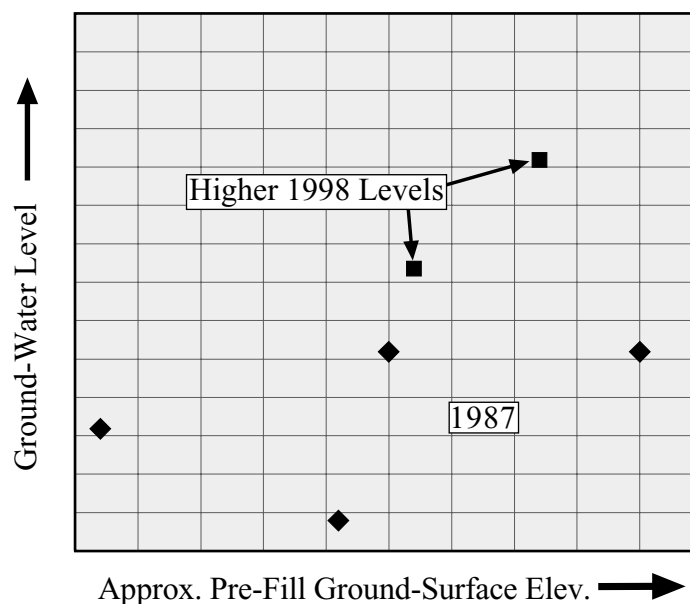
Despite the increased frequency of landsliding throughout the Wasatch Front in 1998, no significant movement occurred at the majority of pre-existing landslides. For instance, at one northern Utah landslide that had been active in 1997, no measurable movement was detected in 1998 despite significantly above-normal precipitation in the area during the year. However, other landslides that were active in 1997, such as the Thistle and Shurtz Lake landslides in Spanish Fork Canyon, experienced renewed movement in 1998. Similarly, in 1983 not all pre-existing historical landslides reactivated. Thus, while the frequency of landsliding, particularly in pre-existing landslide areas, increases with above-normal precipitation, prediction of landslide movement, particularly for a specific landslide, remains difficult.

Lesson three: Site modifications increase the likelihood of landsliding

The majority of the 1998 Wasatch Front landslides occurred where there had been some previous site modifications. In residential areas, site modifications include grading, changes to drainage, and other changes that can influence ground-water levels such as landscape irrigation or the use of septic-tank soil-absorption systems.

Site grading is usually performed to obtain a level area for the house or yard. On slopes, this usually requires either cuts or fills. Cuts at the base of slopes unfortunately remove support from upslope soils and steepen the overall slope angle. Fill soil, usually placed near the top of a slope to enlarge an existing adjacent level area, adds additional weight and also may increase the average slope angle. Site grading also has an indirect effect on ground-water levels. Level areas and permeable fills promote infiltration and can increase the rate that ground-water levels rise due to natural precipitation. Generally, the net result of traditional site grading is a reduction of overall slope stability.

Residential site development changes site drainage in numerous other



Ground-water levels relative to approximate pre-fill ground surface at the Sunset Drive landslide, Layton, indicating higher ground-water levels in the summer of 1998 (squares) than in the spring of 1987 (diamonds). At least part of the increase is likely due to landscape irrigation.

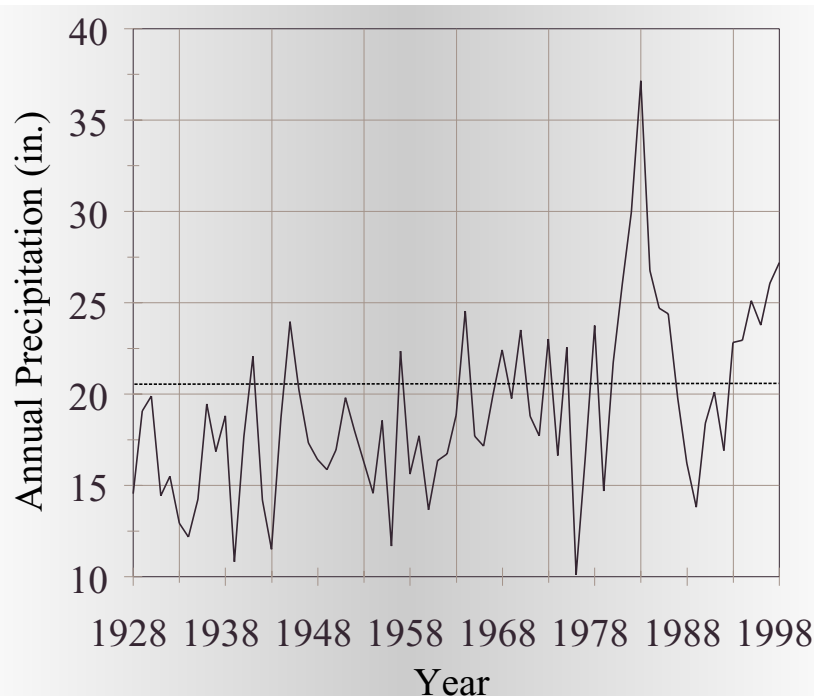
ways. Roofs and paved areas collect, concentrate, and re-direct runoff, often toward nearby slopes. In several of the 1998 landslide areas, flexible pipes attached to downspouts drain directly onto nearby landslides, almost guaranteeing an adverse rise in ground-water levels following a precipitation event. In other cases, re-directed runoff may accelerate erosion and downcutting in natural drainages, increasing the rate of natural slope steepening.

Landscape irrigation also reduces slope stability, particularly over time. The low cost of irrigation water in many communities promotes non-conservative irrigation practices, and homeowners commonly replace natural drought-tolerant vegetation with water-consuming varieties of grasses and garden plants. Thus, excess irrigation water infiltrates slope soils and contributes to a rise in ground-water levels.

Whereas the long-term effects of landscape irrigation on slope stability in Utah have not been adequately documented by geologists, the short-term effects are clearly evident in several 1998 landslide areas. At an active landslide near City Creek in Salt Lake City, wetlands form only in late summer, otherwise the driest part of the

year, likely the result of excess landscape-irrigation water that seeps from the slope. In 1999, the appearance of standing water in the wetlands in the late summer and fall is surprising given that precipitation for the period between June through November was only 44 percent of normal (a precipitation deficit of about 3.7 inches). Thus, landscape-irrigation water appears to have reversed a natural process that otherwise would have likely lowered ground-water levels. Neighborhood residents indicated the wetlands did not exist until relatively recently, indicating a lag of a number of years before the excess landscape-irrigation water caused a ground-water-level rise sufficient to create the wetlands.

Water-level monitoring wells at landslides in Layton and the City of North Salt Lake both show the effect of landscape irrigation in the dry summer and fall of 1999. Precipitation during this period was generally below normal; however, ground-water levels rose from July through September in excess of one foot in some wells. The ground-water-level data confirm that landscape irrigation reverses the natural process of ground-water-level decline in the summer and fall that normally would promote slope stability.



Annual precipitation in Spanish Fork Canyon, 1928-1998. Prior to 1980, above-normal precipitation occurred only in nine separate years. The period between 1980 and 1986 was the first series of years with above-normal precipitation in the historical record dating back to 1928. A similar series began in 1993 and ended in 1998. Dashed line shows mean annual precipitation.

Lesson four: Landslide movement is generally very slow, nearly imperceptible

The rate of landslide movement at the 1998 landslides was, and at some continues to be, generally very slow. Measurements at a landslide in Salt Lake City indicate a maximum average rate of movement of about 2 inches per day, a rate geologists describe as slow. The average rate of movement of the Springhill landslide in the City of North Salt Lake was merely 1/365 inch per day, or very slow. In both cases, landslide movement was imperceptible, or nearly so, but significant landslide damage to residential properties occurred. In the case of the Springhill landslide, obvious landslide features have yet to appear except in asphalt and concrete and at one localized area on a steep slope.

At such slow rates of movement, landslide features that do appear on natural slopes may measure only inches in height. Such features would not be recognizable on aerial photographs typically used by geologists

to identify and classify landslides. This raises the possibility that some pre-existing landslides in undeveloped areas are more active than many geologists may realize.

Protecting the public from landslides

The landslides of 1998 have demonstrated the need for a renewed effort to protect the public from this hazard. Unfortunately, increased growth in the Wasatch Front area has accelerated interest in developing the hillslope areas most vulnerable to landsliding and that may have experienced landsliding in the past. In many communities, residential development is the preferred land use for these areas, despite the fact that residential homeowners commonly lack insurance protection if their houses are damaged or destroyed by landsliding. Local land-use planners face increasing pressure from landowners and developers to allow residential development in areas vulnerable to landsliding. However, developers and local governments need to change their development and construction practices if we

are to reduce the adverse effects of site modifications or avoid “high risk” areas. Clearly, in many communities the risks, particularly to unprotected residential homeowners, are too great. Landslide activity in 1998 has demonstrated that pre-existing landslides must be treated more conservatively if risks to human life and property are to be reduced. Site modifications in these areas resulted in the majority of landslides in 1998 and demonstrated that traditional construction and residential land-use practices (such as landscape irrigation) in Utah do not prevent, and likely promote, landsliding. Whereas pre-existing landslide areas generally represent a small fraction of the available land in most communities, they may be highly sought after for their “view-lot” status. However, it may be best to postpone development in these areas, and continue to promote development in suitable flat-lying areas. During the interim period, new construction and land-use practices as well as an understanding of local instability-triggering thresholds can be established that may allow these areas to be safely developed.

Since 1997, the Utah Geological Survey (UGS) has expanded its research on Utah’s landslides as well as its efforts to reduce landslide hazards in Wasatch Front communities. Currently, UGS geologists are monitoring movement, ground-water levels, and precipitation at four active or recently active landslides. In addition, UGS geologists and technicians are tracking monthly precipitation and snow-pack depths at most of the important Wasatch Front landslide areas in an attempt to recognize potential landslide-triggering precipitation thresholds. The UGS has also expanded its assistance to local communities to ensure that landslide hazards in hillslope areas are adequately addressed prior to development. Wasatch Front communities that the UGS is presently providing technical assistance to include Provo, the City of North Salt Lake, and Layton.

The North Salt Lake Springhill Landslide

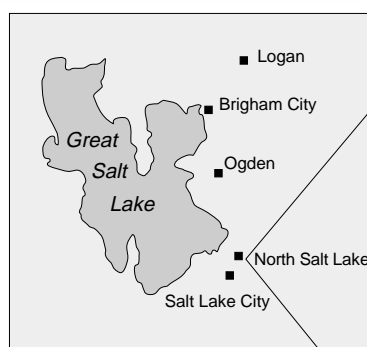
by Richard Giraud

The Springhill landslide is a new landslide that has damaged several houses in a subdivision of the City of North Salt Lake. One house was condemned, and neighborhood homeowners are facing the possibility of watching their houses being slowly destroyed by the slow-moving landslide. Damage to streets, sidewalks, and underground utilities (water, sewer, and natural gas lines) further increases risks to homeowners and the city.

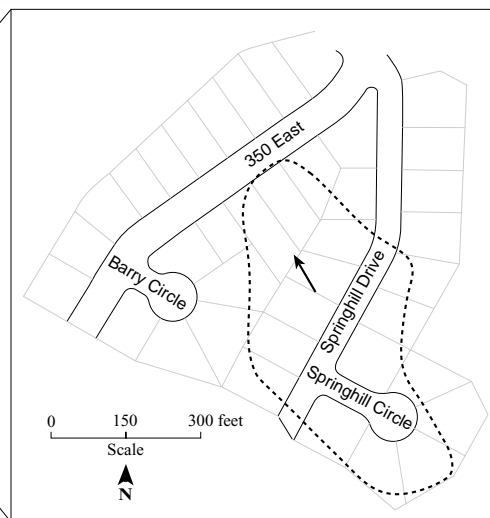
The landslide is located in the Springhill area of North Salt Lake approximately 1/4 mile southeast of the intersection of Highway 89 and Center Street and 1 mile north of the Davis-Salt Lake County line. The landslide extends from Springhill Circle and Springhill Drive downslope to 350 East. The landslide is irregularly shaped with approximate dimensions of 670 feet long by 370 feet wide and has a relatively gentle head-to-toe slope.

Most other landslides in Utah that have moved in the past few years were previously existing landslides that reactivated, but the Springhill landslide is different because it is a new (1998) landslide in an approximately 25-year-old subdivision. The subdivision is a reclaimed gravel pit and is underlain by volcanic rock. The volcanic rock is locally weathered and clay-rich with bedding planes inclined into the hillside. Landslide slip surfaces are in the clay-rich weathered rock but do not appear to follow bedding planes. The Springhill area is appropriately named because of the numerous seeps and springs and shallow ground water.

The landslide is very slow-moving and is still in an early phase of development. Landslide boundaries are not



Location map of the Springhill landslide. Dashed line shows the inferred area of landslide movement and the bold arrow shows the inferred direction of landslide movement.



Landslide-related damage in the north wall of a condemned house on Springhill Drive.



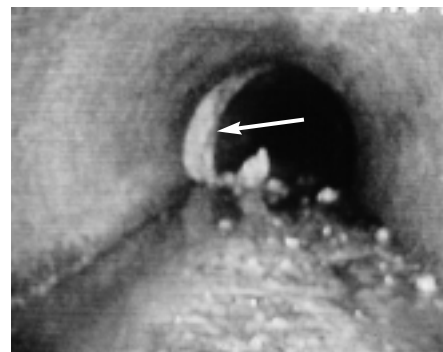
Large crack developed in a concrete foundation wall on Springhill Circle. Wall board has been removed to expose crack. Outside light can be seen through the upper portion of the crack.

well developed at the surface because of the small amount of movement. However, enough movement has taken place to infer landslide boundaries from patterns of building damage, cracks in roads and sidewalks, and subsurface landslide movement as indicated by subsurface instrumentation. Fourteen houses may lie on the landslide but not all show damage. Five houses have significant foundation-wall cracks ranging up to 1/2 inch in width. One of these houses was condemned due to structural damage. Landslide damage includes cracked foundation walls, cracked and offset concrete floors, bowed and skewed door frames, cracked wall board, tipped and bowed retaining walls, and cracked and offset sidewalks, curbs, and gutters. Video surveys of underground sewer lines show offset and cracked concrete sewer pipe at the inferred landslide boundaries along Springhill Drive.

Subsurface monitoring instruments in two boreholes show an inch of downslope movement, from September 1998 through September 1999, at depths of 48 feet in one borehole and 12 feet in the other. This 1 inch per year movement rate is in the southern Springhill Drive and Springhill Circle areas where the highest rates of movement are occurring. Measurements in other boreholes show smaller amounts of movement, or no movement, during the same time period. Homeowners are documenting landslide damage by monitoring the development of new cracks and the propagation and increase in width of existing cracks in their walls and floors. The movement data suggest slow, continuous movement with no seasonal variation. A more complete movement history is needed to accurately define discrete landslide movement areas and determine long-term movement patterns and rates.



The arrow on the sidewalk points in the direction of landslide movement. The sidewalk offset (left-lateral) and bowed shape to the curb and gutter show the amount of landslide movement downslope to the left. View is to the north along the east side of Springhill Drive; the intersection of Springhill Drive and Springhill Circle is in the background.



Video-camera view inside the sewer pipe under Springhill Drive. The offset sewer pipe (arrow) shows the amount of landslide movement. Debris in the foreground is backfill that has spilled into the pipe. Photograph produced from a video tape provided by the South Davis Sewer Improvement District.

So what does the future hold for the Springhill landslide? If the landslide continues to move, additional damage will result. Even if the landslide stops moving, the potential for reactivation is high due to the weakened condition of the established slip surface. Because of the high potential for additional movement and resulting damage, further consideration should be given to landslide mitigation. Also, now that we know landslide-prone materials are present in the area, future development on geologically similar slopes nearby should be evaluated prior to permitting any future development. The Utah Geological Survey continues to work with the City of North Salt Lake to understand this very slow-moving landslide. We must learn from each new landslide that occurs and incorporate that knowledge into the way we develop land so that future homeowners will not suffer as those in the Springhill area have.

HUMAN OCCUPATION ALONG THE OLD RIVER BED

The Environmental Sciences Program at the Utah Geological Survey is cooperating with the U.S. Department of Defense at Dugway Proving Ground in the investigation of early human occupation in the deserts of western Utah. The Old River Bed is the now-dry channel of a prehistoric river that flowed between the Sevier and Great Salt Lake basins for a period of about 3,000 years. Although both basins were occupied by Lake Bonneville at its Pleistocene highstand, the two basins became separated sometime prior to about 12,000 years ago as Lake Bonneville regressed due to changes in climatic conditions. For some time thereafter waters from the Sevier basin flowed northward and emptied into Great Salt Lake, forming an extensive deltaic/marsh ecosystem in what is now the Dugway Proving Ground area. Human foragers, apparently taking advantage of the wide array of resources usually found in Great Basin wetlands, occupied the natural levees along stream distributaries.

There are two different aspects of the project. First, we are attempting to define paleoenvironmental conditions in the Old River Bed delta area and to provide a solid chronological framework for human occupation in the region. So far we have been able to identify two cycles of stream flow in the Old River Bed. The initial cycle was characterized by high-energy stream flow that deposited coarse sands and gravels in channels; these channels have now been exposed through a process called deflation as fine-grained material at the margins of the channel was removed by wind erosion, leaving the coarser-grained channels topographically higher than the current land surface. As yet, this initial cycle is poorly dated, but it likely occurred sometime prior to about 11,400 years ago. The second cycle was characterized by reduced stream flow, possibly derived from ground-water inflow rather than overflow from the Sevier basin, which was only sufficient to carry silts and sands. Fifteen radiocarbon dates on materials associated with these "sand" channels indicate this second cycle lasted from about 10,000 until about 8,800 years ago.

The second aspect of the project involves the survey and



Paleoecological/archeological study in progress, Dugway Proving Ground, summer of 1999.

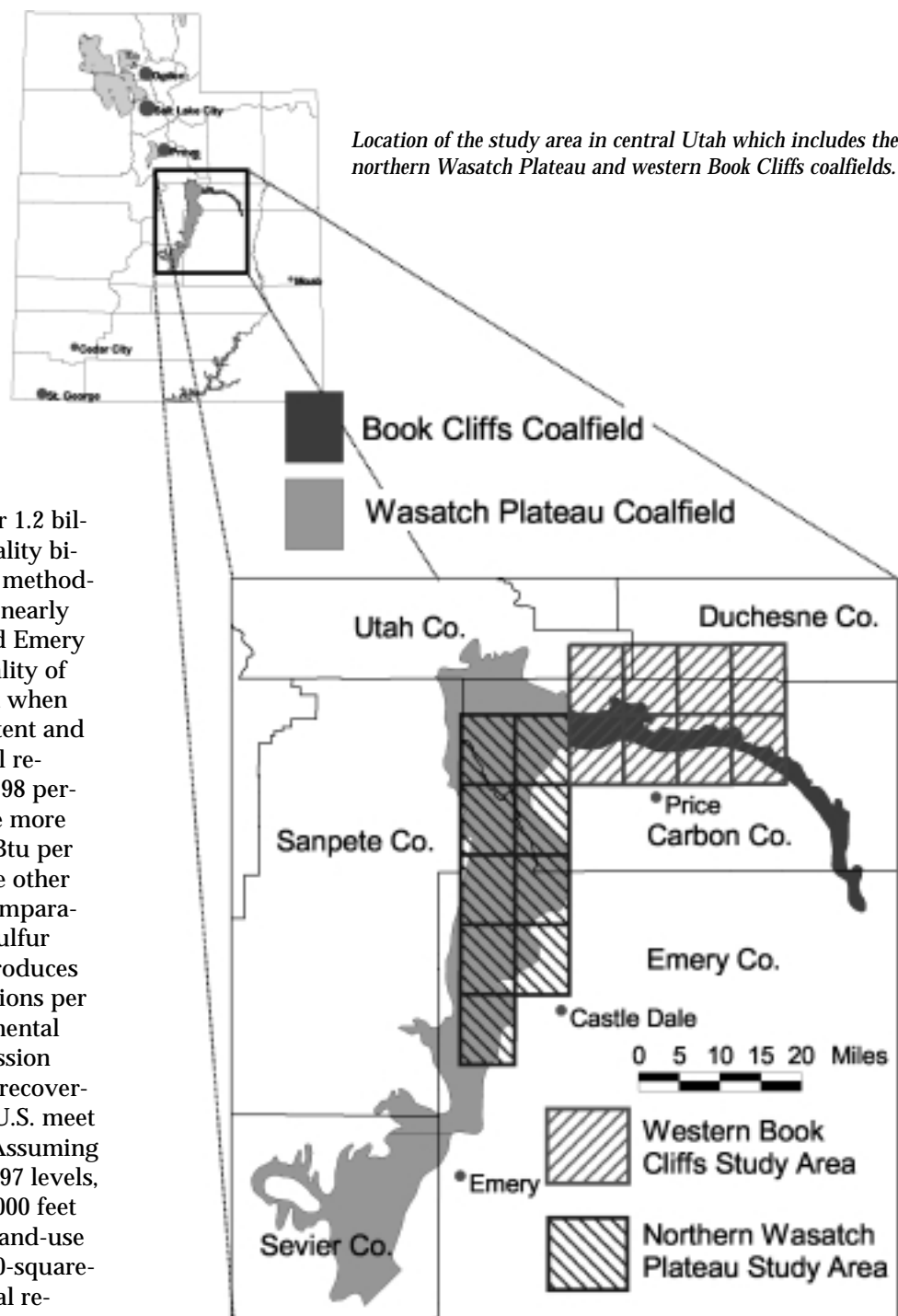
mapping of archaeological sites along these channels. So far we have found sites only along the sand channels. There may have been sites along the gravel channels as well, but the removal of finer-grained materials along the margins of these channels during the deflation process make it impossible to investigate that possibility. The sand channel sites are characterized by an array of chipped stone materials. Many of these are diagnostic of what archaeologists often refer to as the Paleoarchaic period, the earliest known period of human occupation in the Great Basin. These diagnostic tools include Great Basin stemmed projectile points and bifacially (two fronts or surfaces) worked implements from what is called the "Cody Complex," a complex of tools often found in Wyoming. As yet, we are unsure what resources these early foragers were seeking, but the lack of ground stone at the sites suggests that seed procurement was limited and that hunting and the collecting of roots may have been the primary food-collecting activities.

Work on the project will continue this summer and preliminary results should be available in 2001.

Energy News

Quality of Utah's coal superior to most of other U.S. reserves

All coal currently produced in Utah is bituminous in rank and originates from underground mines in the Book Cliffs and Wasatch Plateau coalfields of Carbon, Sevier and Emery Counties. A study recently completed (released next year), funded by the Energy Information Administration (EIA) of the Department of Energy, examined the remaining recoverable coal reserves of the portion of these two fields which accounted for 80 percent of Utah's 1997 annual production. This new study identified over 1.2 billion tons of predominantly high-quality bituminous-rank coal using the EIA's methodology; these remaining reserves are nearly evenly divided between Carbon and Emery Counties. The remarkably high quality of these Utah coal reserves is apparent when comparing both their high heat content and low sulfur content to remaining coal reserves elsewhere in the U.S. About 98 percent of Utah's coal reserves produce more than 23 million Btu per ton (11,500 Btu per pound), while only 28 percent of the other recoverable coal in the U.S. has a comparably high heat content. In terms of sulfur content, 92 percent of Utah's coal produces less than 0.6 pounds of sulfur emissions per million Btu and meets the Environmental Protection Agency's air-quality emission standards, while only 34 percent of recoverable coal reserves elsewhere in the U.S. meet this low level of sulfur emissions. Assuming that coal production continues at 1997 levels, that all coal reserves to depths of 3,000 feet can be recovered, and that no new land-use restrictions are enacted, then the 950-square-mile study area contains enough coal reserves to last until 2047.



Survey News

John Kingsley has joined the UGS as Associate Director, responsible for financial and administrative management. Kingsley earned a master of business administration degree at Westminster College in Salt Lake City and a master's degree in human resource management at the University of Utah. Prior to joining the UGS, he was a budget and accounting officer with the Office of Energy Services. Welcome, John!

You may have noticed that the UGS Board has a new Chair, **Craig Nelson**, who takes over from Bill Berge for a term.

Janine Jarva has accepted a position at the Utah Automated Geographic Reference Center, leaving behind 17 years at UGS in the Applied Section.

Kimberly Urry, our newest intern, worked with the Geologic Extension Service for three months. Degree in hand, she's now off to a new job.

Denise Laes has been diligently digitizing geologic maps and providing GIS expertise for the Mapping Program but was offered a job she couldn't refuse with BP Minerals in Elko, Nevada.

The Wyoming Geological Association announces the upcoming publication of their "Powder River Basin 2000, Oil and Gas Fields Symposium" which will be available September 15 (contact the WGA offices at 307-237-0027).

Survey Notes has been around since August, 1964 as the official newsletter of the Utah Geological Survey. Currently we print about 3000 copies to hand out free. Of that lot, over 200 are mailed to university libraries world-wide, nearly 800 go to geologists or geologic consultants (that we know about - remember to fill in the questionnaire from last issue and send it in), several hundred go to schools or earth science school teachers in Utah and adjoining states, and a

few hundred go to other state and federal agencies. We are quite proud of our little magazine but always welcome suggestions.

Back issues from April, 1996 to the present are available in pdf format on our website at <http://www.ugs.state.ut.us/svnts.htm>

The **RETRO SALE** from the last issue is still going on. That's **\$1.00 !!** for any of the publications listed on the wrapper. Dig out the last issue (volume 32, number 1) and send in an order (& don't forget to fill out the response form while you're there).

Several of our publications are available on CD-ROM for \$5.00 over the price of the publication. The file is in pdf format (portable document file) and may be read on PC or Mac with Adobe Acrobat Reader 4.0 (software is on disk). Advantages are the small storage size, and the searchability of the text. A list is available from the Natural Resources Map/Bookstore.

Utah Geological Survey senior geologist and State Paleontologist Jim Kirkland explains how *Utahraptor* could have gotten to England without getting its feet wet for the Discovery Channel program "*Walking with Dinosaurs*" which aired April 16th. The program highlighted remarkably lifelike computer animations of several lesser known and newly discovered Utah dinosaurs such as *Iguanodon*, *Gastonia*, and *Utahraptor* in their natural habitats along the shores of the proto-Atlantic Ocean. The Discovery Channel brought Kirkland over to England to explain what perfectly good Utah dinosaurs were doing in Europe. Additionally, he also had an opportunity to study the correlation Wealden Group and its fossils, both here on the Isle of Wight and at the British Museum of Natural History. It is remarkable that the closest fossil specimens to what we find in the Early Cretaceous of Utah are known only from these sea cliffs.



"Glad You Asked"

by Carl Ege

How can I stake a mining claim?

Before addressing this question, a prospector or mineral collector must find out who owns the land before exploring the area for its mineral potential. Approximately 67% of Utah's land is controlled by the Federal Government. All of this land is open to prospecting except for National Parks, National Monuments, Indian Reservations, wildlife refuges, wilderness areas, military reservations, reclamation projects, or any other withdrawn areas. All Bureau of Land Management (BLM) land is open to prospecting, except for reclamation projects and land being evaluated for wilderness potential. Most Forest Service land is open, except for vital watershed areas that affect a wide range of wildlife. Also, digging or constructing sluices or dams is not allowed in any National Forest. Special regulations or restrictions may apply for certain areas so check with your local Forest Service district. On lands owned by the state, which include school trust land sections, a mineral lease must first be obtained from the School and Institutional Trust Lands Administration. A mineral lease cannot be granted on state or local parks. On private land, one must first seek permission through the land owner.

Once a mineral deposit has been discovered, land ownership has been verified, and it has been determined that the land is not already claimed, a prospector can stake a claim. When staking a claim on federal lands, location posts or rock monuments are placed at each corner of the claim. A location notice must be placed on one of the corner markers. Location notices contain the following information: (1) date of location, (2) name of locator, (3) name of claim or property, (4) type of claim, (5) acreage claimed, and (6) description of parcel of ground. Within 90 days, a copy of the claim notice must be filed with the BLM and the county recorders office.

Two types of claims can be located: lode and placer. A lode claim includes mineralized veins with well-defined boundaries or broad zones of mineralized rock. A lode claim is 1,500 feet parallel to the vein and 600 feet perpendicular to the vein or outcrop where there is mineralization. All mineral deposits not considered to be lode claims are called placer claims. Placer deposits include unconsolidated materials, such as sand, gravel, gold, or other minerals.

A placer claim is 20 acres in size per locator and an association of eight individuals may claim up to 160 acres.

Before mining begins, a permit must be obtained from the Utah Division of Oil, Gas & Mining for permission to mine on any land in the state regardless of ownership. The cost of this permit depends on the proposed size of the mine.

To maintain possession of a claim on federal land, claim owners must perform at least \$100 worth of improvements or labor to the claim each year. This annual assessment work could include geological, geophysical, or geochemical surveys. After improvements have been completed, the claim owner must file an affidavit of such work with both the county recorder and the BLM. On state lands, a mineral lease must be renewed each year.

Agencies to contact for further information:

- (1) Staking claims on federal land and land ownership:
U.S. Bureau of Land Management
Utah State Office
Coordinated Financial Services Building
324 South State Street #401
Salt Lake City, UT 84111-2303
(801) 539-4001
- (2) Permits for mining or exploration on all land in Utah:
Utah Division of Oil, Gas & Mining
1594 West North Temple, Suite 1210
P.O. Box 145801
Salt Lake City, UT 84114-5801
(801) 538-5340
- (3) Prospecting on Forest Service lands:
U.S. Forest Service
8236 Federal Building
125 South State Street
Salt Lake City, UT 84138
(801) 524-5030
- (4) Permission to prospect on state lands:
School and Institutional Trust Lands Administration
675 East 500 South, Suite 500
Salt Lake City, UT 84102-2818
(801) 538-5100



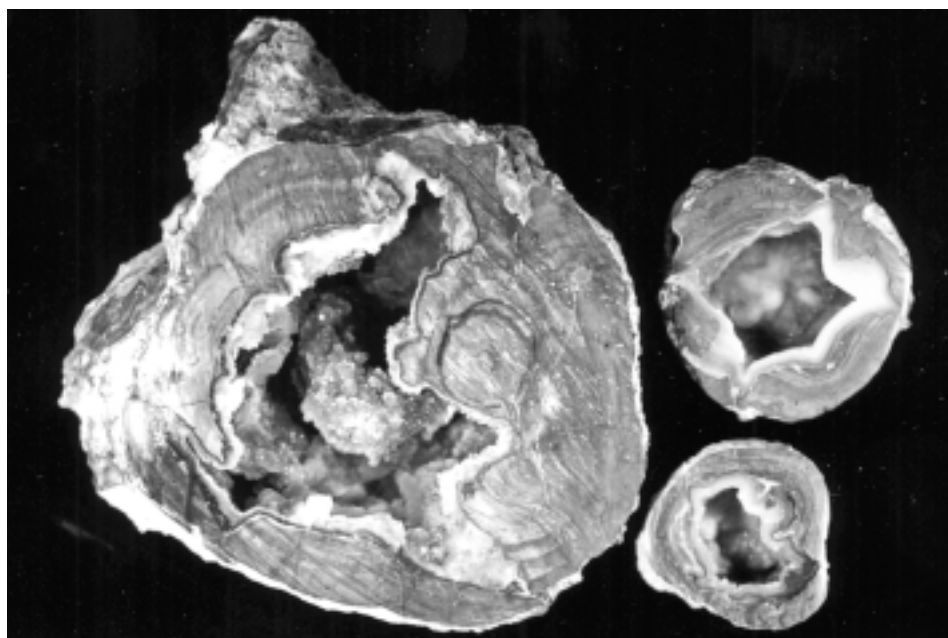
The Rockhounder

by Carl Ege

Dugway Geode Beds, Juab County

Geologic information: Approximately 6 to 8 million years ago (Miocene epoch), volcanic activity occurred in western Utah and deposited an extrusive igneous rock called rhyolite. Trapped gasses formed cavities within the rhyolite, and millions of years of ground-water circulation allowed minerals to precipitate into the cavities. The result is geodes with spherical shapes and crystal-lined cavities. Roughly 32,000 to 14,000 thousand years ago, a large body of water known as Lake Bonneville covered most of western Utah. The lake's wave activity eroded the geode-bearing rhyolite and redeposited the geodes several miles away in the Dugway geode bed area as lake sediments. Most geodes are typically hollow whereas others are completely filled with massive, banded quartz. The most common mineral found within the geodes is quartz in various colors: clear (rock crystal), purple (amethyst), and pink (rose).

How to get there: From Salt Lake City take I-80 westbound until you reach the Tooele turnoff (exit 99). Travel south on Highway 36 for about 40.5 miles to the Pony Express Road (which is the dirt road just past Faust). Turn west (right) and proceed 50.1 miles on the Pony Express Road to the Dugway geode bed turnoff. Turn north (right), proceed up the dirt road and look for recent diggings.



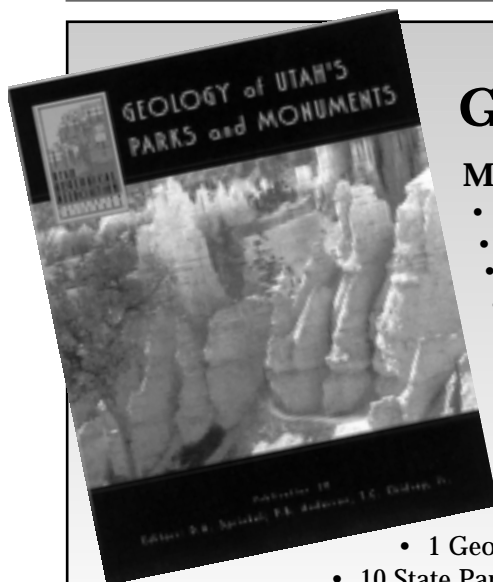
Dugway geodes cut in half to show quartz-lined cavities. Largest geode is approximately six inches in diameter.

Recently, people have bypassed the turnoff because the sign to the geode bed area was missing. Please note at the time of this writing, there is a temporary sign indicating the correct direction to the geode bed area; however, please use your vehicle's odometer to determine distance to the geode bed turnoff.

Where to collect: Geodes can be found approximately 1 to 2 miles north/northeast of the turnoff. The easiest technique is to find an area of past excavations and start digging to locate the proper horizon where the

geodes can be found. You will be digging in a soft, unconsolidated material that is susceptible to caving, so please be careful! Examine all stones that are encountered. The geodes are fairly easy to recognize due to their spherical shape and light weight. Most geodes are 2 to 3 inches in diameter and are typically lined with small quartz crystals that give the cavity a sugary appearance. I collected fragments and whole geodes near UTM map coordinates 12S 0317569 4416919.

Continued on next page....



Utah Geological Association Publication 28

GEOLOGY OF UTAH'S PARKS AND MONUMENTS

Millennium Guidebook

- Publication in September 2000
- 25 Parks and Monuments
- Soft color cover
- Editors - D.A. Sprinkel, P.B. Anderson, and T.C. Chidsey, Jr.
- Full color, approximately 550 pages
- 8 additional topical appendices
- Includes compact disk with road, trail, and lake logs
- Guidebook price is \$28

Anticipated articles

- 5 National Parks - Arches, Bryce Canyon, Canyonlands, Capitol Reef, and Zion
- 6 National Monuments - Cedar Breaks, Dinosaur, Grand Staircase - Escalante, Natural Bridges, Rainbow Bridge, and Timpanogos Cave
- 2 National Recreation Areas - Flaming Gorge and Glen Canyon
- 1 Geologic Area - Sheep Creek Canyon
- 1 Tribal Park - Monument Valley
- 10 State Parks - Antelope Island, Coral Pink Sand Dune, Dead Horse Point, Escalante, Goblin Valley, Goosenecks, Kodachrome Basin, Quail Creek, Snow Canyon, Wasatch Mountain

For more information contact Tom Chidsey at 801-537-3364 or visit the UGA Web Page at www.ugs.state.ut.us/uga.html

Continued from previous page....

Useful maps: Fish Springs 1:100,000-scale topographic map, Dugway Pass 1:24,000-scale topographic map, and a Utah highway map. These maps may be obtained from the Natural Resources Map & Bookstore, 1594 W. North Temple, Salt Lake City, UT 84116, (801) 537-3320 (or 1-888-UTAH-MAP).

Land ownership: Bureau of Land Management (BLM) public lands. Active mining claims exist on some portions of the "geode area" so seek permission from the claim owners before collecting. For more information on

BLM public lands under claim contact the House Range/Warm Springs BLM field office at (435) 743-3100.

BLM collecting rules: The casual collector may take small amounts of petrified wood, fossils, gemstones, and rocks from unrestricted federal lands in Utah without obtaining a special permit if collection is for personal, noncommercial purposes. Collection in large quantities or for commercial purposes requires a permit, lease, or license from the BLM.

Miscellaneous: Tools recommended: a shovel, pick, safety glasses and hammer (in case you want to break

your geodes on the spot). Whole geodes can be taken to your local rock shop to be cut in half. Bring plenty of water and remember to bring a spare tire in case of an unforeseen accident. More importantly, be patient and have fun collecting!

Note: This is the last Rockhouser column to appear in Survey Notes. The column will be replaced by another describing geologic points of interest in Utah. For continued rockhouser information, contact the Natural Resources Map & Bookstore for a selection of rock and mineral collecting guides.

New Publications from the UGS

Digital geologic map of Utah, by L.F. Hintze, G.C. Willis, D.Y.M. Laes, D.A. Sprinkel, and K.D. Brown, 1 CD-ROM, 2000, M-179DM \$19.95

Paleoseismology of Utah Volume 9: Paleoseismic investigation of the Clarkston, Junction Hills, and Wellsville faults, West Cache fault zone, Cache County, Utah by B.D. Black, R.E. Giraud, and B.H. Mayes, 23 p., 1 pl., 3/00 SS-98 \$10.50

Geologic map of the Picture Rock Hills quadrangle, Juab County, Utah by M.A. Shubat, 22 p., 2 pl., 1:24,000, 1/00 MP-99-3 \$7.50

Geologic map of the Keg Pass quadrangle, Juab County, Utah by M.A. Shubat and G.E. Christenson, 28 p., 2 pl., 1:24,000, 1/00 MP-99-4 \$8.75

Geologic map of the Keg Mtn. Ranch quadrangle, Juab County, Utah by M.A. Shubat, T.J. Felger, and J.K. King, 22 p., 2 pl., 1:24,000, 1/00 MP-99-5 \$7.50

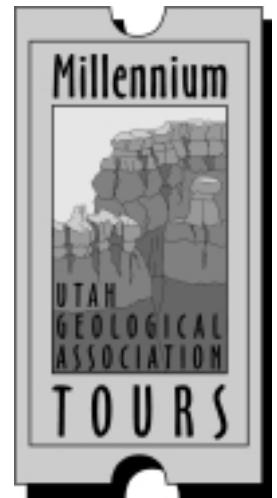
Technical reports for 1999, Applied Geology Program, compiled by G.N. McDonald, 85 p., 2/00 RI-244 \$7.50

Rock-fall hazards, by W.F. Case, 2 page color information sheet, 4/00 PI-69 Free



Teacher's Corner

**SCIENCE TEACHERS of Grades 1- 12 are invited to attend
Geologic-Content/Processes field trips
September 15, 16, 22, and/or 23, 2000 for Credit**



The Utah Geological Association (UGA) is celebrating the millennium with four field trips to Utah's parks and monuments in September. Teachers are invited to attend on one or two days at a reduced cost, and receive inservice credit upon completing assignments.

Tour 1 - Moab area - September 15 (Friday) and/or September 16 (Saturday)

Arches & Canyonlands National Parks, and Dead Horse Point State Park. Transportation available from/to Salt Lake City on Thursday and Sunday (\$270 w/lodging), or teachers may join group in Moab for Friday and/or Saturday.

Credit: 0.5 Hour Inservice/1 day or 1.0 Hour Inservice/2 days.

Fee: \$37 one day/ \$50 two days*

Tour 2 - Wasatch Front - September 15 (Friday) and/or September 16 (Saturday)

This trip will examine the unique geologic features of Antelope Island State Park on Saturday, and Friday will be spent at Wasatch Mountain State Park and Timpanogos Cave National Monument.

Credit: 0.5 Hour Inservice/1 day or 1.0 Hour Inservice/2 days.

Fee: \$45 one day/ \$78 two days

Tour 3 - Vernal area - September 22 (Friday) and/or September 23 (Saturday)

Dinosaur National Monument, Flaming Gorge National Recreation Area, Sheep Creek Canyon Geologic Area, and Red Fleet State Park. Transportation is available from/to Salt Lake City on Thursday and Sunday (\$238 with lodging), or teachers may join the group in Vernal for Friday and/or Saturday.

Credit: 0.5 Hour Inservice/1 day or 1.0 Hour Inservice/2 days.

Fee: \$37 one day/ \$50 two days*

Tour 4 - St. George area - September 22 (Friday) and/or September 23 (Saturday)

Zion National Park, Cedar Breaks National Monument, Snow Canyon and Quail Creek State Parks. Transportation is available from/to Salt Lake City on Thursday and Sunday (\$265 with lodging), or teachers may join the group in Zion area for Friday and/or Saturday.

Credit: 0.5 Hour Inservice/1 day or 1.0 Hour Inservice/2 days.

Fee: \$36 one day/\$46 two days*

*Fee does not include transportation.

For more information on the trips, visit the UGA's Millennium web site www.vii.com/~sprinkel/uga2000web. For teacher-specific information, contact Sandy Eldredge at the Utah Geological Survey, 801-537-3325, nrugs.seldredg@state.ut.us.

Pre-register now to reserve a space and to insure receiving additional information.



PRE-REGISTER now. Mail in this completed form, or call, email, or fax the following information:

Send to/contact Sandy Eldredge, Utah Geological Survey, PO Box 146100, Salt Lake City, UT 84114-6100. Phone 801-537-3325, fax 801-537-3400, nrugs.seldredg@state.ut.us

Name _____

School _____ District _____

Address _____

City _____ Zip code _____

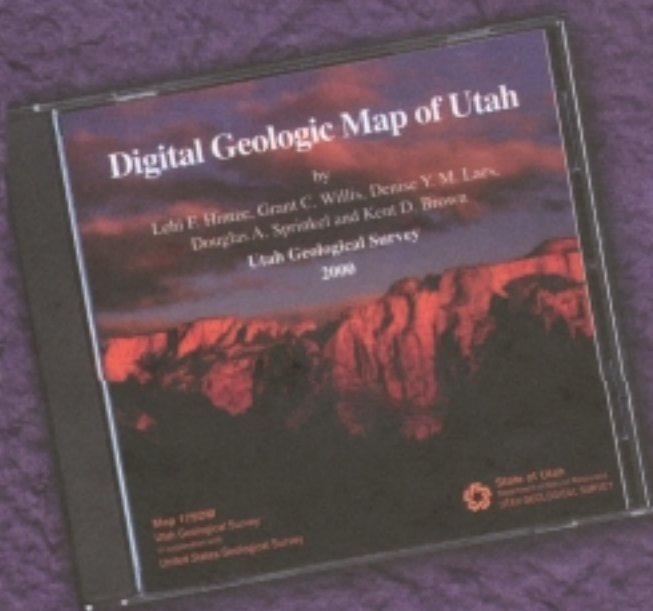
Daytime phone _____ Fax _____

E-mail address _____

Check which field trips: **Moab** Fri. ☐ Sat. ☐ **Wasatch Front** Fri. ☐ Sat. ☐ **Vernal** Fri. ☐ Sat. ☐ **St. George** Fri. ☐ Sat. ☐

Studying geology just got easier.

THE DIGITAL GEOLOGIC MAP OF UTAH



The Utah Geological Survey (UGS), in cooperation with the U.S. Geological Survey, has created a digital geologic map of Utah. Geologic maps are the basic tools of geologists and are the foundation of all geologic research. The maps are used extensively in exploration, land management and planning.

The new map is a digital version of the commonly used state geologic map created in 1980 by Dr. Lehi F. Hintze, the "father of Utah geology," and a former BYU professor and UGS mapping scientist.

The digital map is available on a CD-ROM with an easy-to-use menu. The CD includes a variety of free software (Acrobat Reader® and ARC/Explorer®) and supporting data and explanation files. The map is provided in three versions on the disk: a version that can be viewed with the Acrobat Reader software, an ARC/Explorer® project file version, and a GIS-compatible version.

THE DIGITAL GEOLOGIC MAP OF UTAH can be ordered for \$19.95 plus tax and shipping.

THE DIGITAL GEOLOGIC RESOURCES ATLAS OF UTAH

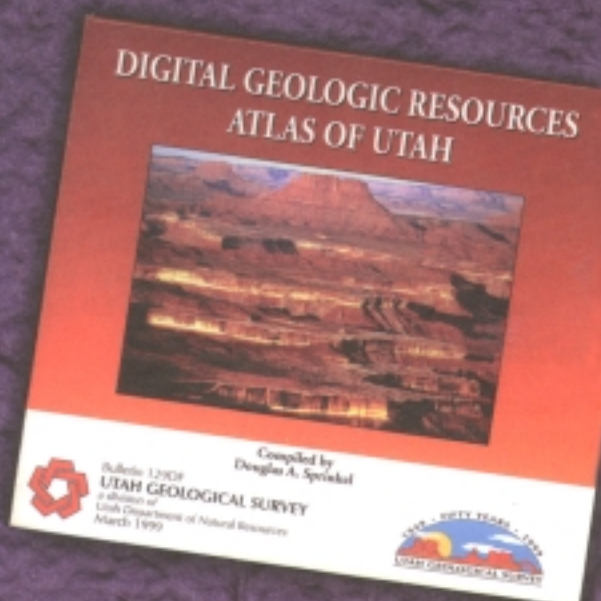
The Digital Geologic Resources Atlas of Utah contains over 600 megabytes of ArcView® shape files gleaned from geologic resource data that have been collected for more than 50 years by the Utah Geological Survey, U.S. Geological Survey, U.S. Bureau of Mines, and the Bureau of Land Management. Among the layers are:

- Coal • Geothermal • Mineral
- Oil and Gas • Oil Shale • Tar Sands
- County Boundaries • Cities and Towns
- Roads • Streams and Bodies of Water
- Land Ownership and Management

This CD-ROM is ideal for government agencies and mineral and energy exploration companies.

The Atlas is the first of several new digital products of the Utah Geological Survey and comes with ArcExplorer®.

THE DIGITAL GEOLOGIC RESOURCE ATLAS OF UTAH is available for \$49.95 plus tax and shipping.



Utah Geological Survey
1594 W. North Temple, Suite 3110
Box 146100
Salt Lake City, UT 84114-6100
Address correction requested
Survey Notes

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